Green Building assessment tools: Evaluating different tools for green roof system

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Abstract. Intense progress, technological competition and globalization had incurred dramatic changes in building technology. The issues of building sustainability's have been a major subject of debates and arguments among the practitioners. The emergence of green building assessment tools have somehow given the guidelines and foundation for a building to be certified as a sustainable building or in the new term would be called as green building. One important component in green building is the green roof system. How far the existing assessment tools evaluating and credit to the green roof system will be analyzed in this study. The establish assessment tools such as Building Research Establishment Environment Assessment Method (BREEAM), Leadership in Energy and Environmental Design (LEED), CASBEE, BCA Green Mark and Malaysian very own Green Building Index (GBI) will be compared among each other to determine which tools give higher marks for green roof technology. The result of this study will enables to determine in which assessment tool that gives most priority and benefits to developers when implementing green roof system.

Introduction

Urban development has spurred the urgent need of creating and developing sustainable building. The construction industry had been identified as the main culprit in the deterioration of earth environment and being the major contributor to pollution (Ding, 2008). In the last couple of decades, with the objective to enhance sustainable building or the so called "green building" has led several government and non-profit organization to the emergence of green building assessment tools.

Green building primarily having energy efficient usage, water conserving, the use of recyclable materials, non-toxic and other features that contribute to the environmental, social and economics (Ali & Al Nsairat, 2009). The question arises when to compare a green building and a normal building. Therefore the emergence of green building assessment tools had helped the development of green building assessment to compare to a normal traditional building and the method to compare and distinguish between the green features between them (Reed, Bilos, & Wilkinson, 2009).

The last couple of decade had seemed tremendous growth of building sustainability assessment tools. The first recognized tools had emerged in 1990 with the latest tools being Malaysia's Green Building Index (GBI) in January 2009 (GBI, 2013). With the conscious and awareness among personnel whom involved with the building development, the trend of developing new tools in other developing countries will be emerging from time to time. Benchmarking process of the building assessment tools is in need across nation in order to ensure the level of certification of building is well developed and recognized with other reputable scheme available worldwide. However it is important to mention that the availability of assessment tools tend to differ due to principles and concept of one tools developed. It is also considers the criteria, items evaluation and data (Sinou & Kyvelou, 2006).

One of the earliest and most profound assessment tools is the UK's Building Research Establishment Environment Assessment Method (BREEAM) developed in the year 1990. The main function of this assessment tools are primary on building specification evaluation including the design, construction and use (BREEAM, 2013).The vast experience of BREAAM in building assessment has lead its methodology to be the foundation of the new building assessment tools in Canada, Hong Kong, Australia and many other countries (Ding, 2008).

Leadership in Energy and Environmental Design (LEED), the second oldest tool was available in the year 1998 which was Developed by United States Green Building Council (USGBC). Up to date, there are 135 countries implementing LEED certification assessment tools. Similar to BREEAM, LEED has also been the earliest model that is being adopted and modified accordingly to one countries environment and nature (Reed et al., 2009).

Japan as one of the most developed country is Asia has come up with their rating tool known as Comprehensive Assessment System for Building Environment Efficiency (CASBEE) in the year 2001. One of the first tools emerged in Asian region and the reliability of the tool have gained reputable status as BREEAM and LEED. The rating tool is mainly focused in green building certification in Japan and Asia (CASBEE, 2013).

Green Mark was initiated in the year 2005 by Building and Construction Authority of Singapore. It was the first tool developed in South East Asian region. The emergence of this tool has encouraged other countries in the South East Asian region to develop their own rating tool. One of it is Malaysian Green Building Index (GBI).

Green Building Index (GBI) in Malaysia is one of the new rating tools available in the market. The rating tool was developed by Malaysian Institute of Architects (PAM) and The Association of Consulting Engineers Malaysia (ACEM). The GBI ratings are mainly two type, which are building and township. The main objectives of GBI is as a way to enhance and promoting the sustainable built environment as well as igniting the awareness for every parties involved with buildings about the issues in environments and sustainability for the future generations (GBI, 2013).

This study will identify which assessment tools give most credit to green roof system. Factors of climate, environment and government policies may have significant effect to the value of green roof with different assessment tools. Previous study on difference of rating tools had been done as like of (Reed et al., 2009) that compare on eleven different rating tools. (Lee & Burnett, 2008) compared three tools, (Sinou & Kyvelou, 2006) compared six rating tools, (Mao, Lu, & Li, 2009) compared six tools and many other studies that compared several rating tools that is available currently in the world. Most compared tools are BREEAM, LEED, and CASBEE because of the reliability of these tools that come from fully developed countries of UK, United States and Japan. Even though many have done the comparison, usually the comparisons are between the rating tools as a whole and mostly on energy

efficiency. The comparison assessments of green roof have not been done as for now. The need to compare which rating tools give the highest credits for green roof to the overall score must be identified to ensure which country benefited the most from green roof system application. This will give mileage and credits to developers and practitioners in the country to implement the green roof system. There are certain limitations in term of comparing the assessment tools because of different focus and concern of difference rating tools.

Green Roof

Green roof system is one of the new methods in building construction. The system has been widely implemented in developed countries such as UK, Unites States, Canada and several other European countries. This system has been hugely accepted in many other countries in the world including Malaysia.

The difference of green roof compared to a conventional roof is that green roof implements plants and vegetation on top of the structure. Growing medium and soil are also embedded according to the type of green roof system. The types of green roof are extensive and intensive. The difference is according to its type of plants and vegetation and its soil depth measurement.

Extensive green roof shallow soil depth, and consist of sedum based covering and small plants. The system requires less maintenance (Bianchini & Hewage, 2012; Molineux, Fentiman, & Gange, 2009; Whittinghill & Rowe, 2011). Another type of green roof is semi extensive or semi intensive. This roof having 25% covering of the total roof with green areas (Bianchini & Hewage, 2012).

New building for assessment. Different tools have many concepts and focus on types of building and construction. This study will focus on new building for comparing all the assessment tools. The new building is chosen because of its ability to adapt to the available assessment tools. The main objectives of the available new building rating tools are to reduce the life cycle impacts of new building construction on the environment. Applying it in the most cost effective and robust manner.

The version selected is also the current version available of the tools. It is difficult to assess the current available building because of the old design, obsolete technology and cultural perspective. The five tools that is being evaluated in this study will be BREEAM UK new construction 2011, LEED new version for construction v2009, CASBEE for new building construction (2010), BCA Green Mark for New Non-residential building (version NRB/4.1) and GBI Non-Residential New Construction (NRNC) version 1.05. The following table 1 summarizes the version selected for all the tools compared in this study.

Table 1. Version of different tools selected for comparison

	Tools	**Version**
1	BREEAM	BREEAM UK new construction 2011
2	LEED	LEED new version for construction v2009
3	CASBEE	CASBEE for new building construction (2010
4	Green Mark	BCA Green Mark for New Non-residential building (version NRB/4.1)
5	GBI	Non-Residential New Construction (NRNC) version 1.05

Categories of Green Building Assessment tools

BREEAM and LEED are the most common green building assessment tools. According to (Lee & Burnett, 2008) these two schemes is leading the frontrunner because of three factor. The first is due to its vast coverage of issues especially environment. Secondly, the wide scope of covered building and thirdly the profound difference in assessment scope and criteria among the schemes.

In this study, the focus will be on the credits given by all these tools to green roof system on the green building. The percentage of credits given for green roof for a particular rating tool will be evaluated among each other. The difference between them could ponder a question of climate differences, government policies and also a countries culture in implementing certain new technologies.

BREEAM. Since BREEAM was first launched in 1990, the assessment rating has certified up to 200,000 buildings and more than a million had registered for the certification process (BREEAM, 2013). This has secured and steadfast the rating tools as the distinguished rating tools available in the world. The comprehensive assessment of this tool includes all criteria from energy to ecology. This includes main aspect of management processes, water use and energy, health and wellbeing, transport, pollution, ecology and waste.

Table 2 below shows the rating benchmark of building for BREEAM certification. The rating have been identified as outstanding which a building have to obtain score of more than 85% and the lowest rated as unclassified at below as 30% of scores.

Table 2. BREEAM rating benchmarks

Rating	% Score
Outstanding	≥ 85
Excellent	≥70
Very Good	≥55
Good	≥45
Pass	≥30
Unclassified	<30

BREEAM weighting is 100% which consist of 9 criteria of environmental aspect. With energy, health and wellbeing, management, and materials section give more than half of the total points in BREEAM certification. Table 3 below presents the weighting of the criteria in BREEAM assessment system.

Table 3. BREEAM Environmental section weightings

Environmental section	Weighting
Management	12%
Health & Wellbeing	15%
Energy	19%
Transport	8%
Water	6%
Materials	12.5%
Waste	7.5%
Land Use & Ecology	10%

Pollution	10%
Total	100%
Innovation (additional)	10%

LEED. The first version of LEED was launched in August 1998 at US Green Building Council (USGBC) membership summit. Since the inaugural commencement, LEED had developed to be one of the reliable tools among the main players in the construction business. Up to date the tool have wide range of coverage of building which include major renovation projects (LEED-NC), existing building operations (LEED-EB), commercial interiors projects (LEED-CI), core and shell projects (LEED-CS), homes (LEED-H) and neighborhood development (LEED-ND) (LEED, 2013; Sinou & Kyvelou, 2006). The LEED new version for construction v2009 will be evaluated in the study.

The rating awarded in LEED rating ranging from Platinum, Gold, Silver and certified. The required points for a building to be certified is 40 points and the highest rating would be 80 and more to obtain platinum rated. Table 4 below present the rating and points for LEED tools

Table 4. LEED rating system

Rating	**Points**
Certified	40–49 points
Silver	50–59 points
Gold	60–79 points
Platinum	80 points and above

The primary concern in LEED rating tools is the energy & atmosphere and sustainable sites which make up 51% from the cumulative 110%. The parameters of criteria are listed in table 5.

Table 5. LEED criteria points

	CRITERIA	**POINTS**
1	Sustainable sites	26
2	Water efficiency	10
3	Energy & atmosphere.	35
4	Materials & resources.	14
5	Indoor environmental quality credits	15
6	Innovation in Design	6
7	Regional Priority	4
	Total	**110**

CASBEE. The first development of assessment tool in Asia has been developed in Japan in the year 2001. The method applied in CASBEE differs greatly from other tools. It applies the Building environmental efficiency (BEE). The scores will be resulted from the BEE values depending on the environmental load (L) and quality of building performance (Q). L is divided into L_1= energy, L_2=resources and materials and L_3= off-site environment. Q is divided into Q_1= indoor

environment, Q_2=quality of services and Q_3= outdoor environment on site. The calculation of a building according to BEE is as following the equation below.

$$BEE = \frac{Q: Building\ environmental\ quality\ and\ performance}{L: Building\ environmental\ loadings} = \frac{25\,x\,(S_q - 1)}{25\,x\,(5 - S_{LR})}$$

From the equation, BEE values are represented by plotting on a graph. A building is considered sustainable when getting a steeper slope, which is achieved by getting higher value of Q and lower value of L. The following figure 1 shows a graph evaluation of a BEE certification system

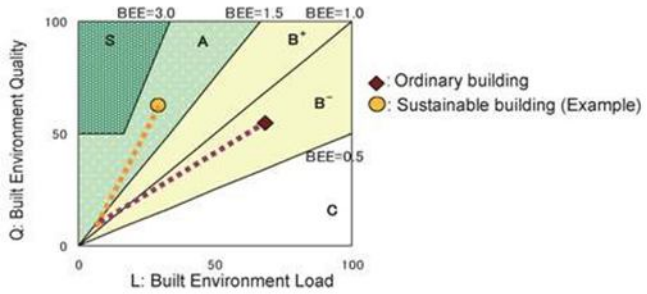

Figure 1. CASBEE home page, retrieved 2013

The certification of CASBEE building evaluation are given as S for excellent, A for excellent, B^+ for Good, B^- for Fairy poor and C for Poor. The following table 6 shows the level of certification under CASBEE building assessment scheme and table 7 shows the assessment items in CASBEE rating.

Table 6. Rating for CASBEE building scheme

Ranks	Assessment	BEE value	Expression
S	Excellent	BEE= 3.0 or more and Q=50 or more	*****
A	Very good	BEE=1.5-3.0 BEE=3.0 or or more and Q is less than 50	****
B+	Good	BEE=1.0-1.5	***
B	Fairy Poor	BEE=0.5-1.0	**
C	Poor	BEE=less than 0.5	*

Table 7. Assessment items for CASBEE rating

Q	**Built environment quality**	**Weighting**	
		Non factory	factory
Q1	Indoor environment	0.4	0.3
Q2	Quality of service	0.3	0.3
Q3	Outdoor environment on site	0.3	0.4

LR	Built environment Load	Weighting
LR1	Energy	0.4
LR2	Resources and material	0.3
LR3	Off-site environment	0.3

Green Mark. The main aim of the Building Construction Authority is to provide certification standards for the developing friendly environmental practice in the planning, design and construction of a building. This in turn would able to reduce and hence eliminate the environmental impacts of built structures (BCA Green Mark, 2013). Table 8 below shows the BCA Green Mark award rating.

Table 8. BCA Green Mark award rating.

Green mark Score	Green Mark Rating
90 and above	Green Mark Platinum
85 to <90	Green Mark Gold plus
75 to <85	Green Mark Gold
50 to <75	Green Mark Certified

Green mark point allocation is divided into two categories, residential and non-residential. For this comparison, non-residential criteria will be taken. Table 9 displays the points allocation for BCA Green Mark.

Table 9. Framework and point allocations for Non Residential building criteria BCA green mark

Category	Part	Points
Energy related requirements	Part 1: Energy efficiency	116
Other green requirements	Part 2: Water Efficiency	17
	Part 3: Environmental protection	42
	Part 4: Indoor environmental quality	8
	Part 5: Other green features	7
Total points		190(max)

Green Building Index (GBI). The emergence of Green Building Index (GBI) in the year 2009 had promoted Malaysian developers, planners, and those who involve directly with built structures to obtain certification.

The primary objective of GBI is to promote sustainability built environment and bring all the major players in the industry towards the environmental issues. The developed GBI as a rating tool in the country will enable developers to design and construct sustainable, green buildings that can give credits to the energy savings, water saving, healthy indoor environment, good connectivity to the public transport and greenery features for developing such projects which include recycling and reusing materials (GBI, 2013). The following table 10 and 11 display the ratings given by GBI tool and its points allocation for sustainable features.

Table 10. Rating of GBI assessment tool

Points	GBI Ratings
86+ Points	Platinum
76 to 85	Gold
66 to 75	Silver
50 to 65	certified

Table 11. Points allocations for GBI tool

Part	ITEM	Max Points
1	Energy efficiency (EI)	35
2	Indoor Environmental Qualit (EQ)	21
3	Sustainable Site Planning & Management (SM)	16
4	Material & Resources (MR)	11
5	Water Efficiency (WE)	10
6	Innovation (IN)	7
	Total Points	100

All the five tools considered in this study have basically the same foundations of sustainable features. The difference can be found in term of specific criteria being assessed. The following table 12 presents brief summary of the five sustainable rating tools of BREEAM, LEED, CASBEE, Green Mark and GBI.

Table 12. Summary of assessment criteria for green building tool

BREEAM	LEED	CASBEE	Green Mark	GBI
1. Management 2 Health & Wellbeing 3. Energy 4. Transport 5. Water 6. Materials 7. Waste 8. Land Use & Ecology 9. Pollution	1. Sustainable sites 2.Water efficiency 3. Energy & atmosphere. 4. Materials & resources. 5. Indoor environmental quality credits 6. Innovation in Design 7. Regional Priority	Built environment quality 1. Indoor environment 2. Quality of service 3. Outdoor environment on site Built environment load: 1.Energy 2. Resources & materials 3. Off-site environment	Part 1: Energy efficiency Part 2: Water Efficiency Part 3: Environmental protection Part 4: Indoor environmental quality Part 5: Other green features	1. Energy efficiency 2. Indoor environmental quality 3.Sustainable site& management 4. Materials & resources 5.Water efficiency 6. Innovation

The difference in assessing sustainable features is due to many factors. Some of the tools have been transformed many times due to current requirements since the year of its inception. Others include the country of origin, developers of the tools and according to the geographical factors of the tools. Table 13 summarizes all the five building assessment tools.

Table 13. Summary of environmental building assessment tool

	BREEAM	**LEED**	**CASBEE**	**Green Mark**	**GBI**
Year commence	1990	1998	2001	2005	2009
Country originated	UK	USA	Japan	Singapore	Malaysia
Developed by	Building Research Establishment (BRE) Ltd	U.S Green Building Council (USGBC)	Japan Sustainable Building Consortium (JSBC)	Building Construction Authority (BCA) Singapore	Malaysian Institute of Architects (PAM) and The Association of Consulting Engineers Malaysia (ACEM)
Geographical focus	National	National	Global	Local, Singapore and nearby region	National
Characteristics	Two process of assessment. Design stage and post construction	A voluntary tool constitute of 5 sustainability areas. Industrial standard certification process	Primarily on environment concern. Having 3 stages of development	Designed for construction personnel and planners	Designed specifically for tropical climate.
Building type	Offices, retails, industry units, courts, educations, healthcare, prison,	Healthcare facilities, schools, homes, entire neighborhoods.	Residential and non-residential type of building	Almost all building type	Two main assessment, building and township
Reference	(BREEAM,2013), (Mao et al., 2009)	(LEED, 2013), (Ding, 2008)	(CASBEE, 2013), (Ding, 2008), (Sinou & Kyvelou, 2006)	(BCA Green Mark, 2013)	(GBI, 2013)

Result

The following table shows the related points given for green roof application in all the green building rating tools.

Different tools give different terms for sustainable criteria where in fact the meaning and function is primarily the same. Examples shown for BREEAM, where it states the water efficient equipment can be incorporated with green roof system. Whereas in LEED, the criteria benefited for green roof is from water efficient landscaping. These two criteria provide opportunities for green roof system construction. The following table 14 to 18 presents the points allocation for green roof system from five different building assessment tools.

Table 14. BREEAM

Criteria	Scope	Criteria	Available Credits
8.0 Water	Wat 04	Water efficient equipment	1
9.0 Materials	Mat 04	Insulation	2
11.0 Land Use and Ecology	LE 05	Long term impact on biodiversity	2
12.0 Pollution	Pol 03	Surface water run off	5
	Pol 05	Noise attenuation	1
Total Points			11

Table 15. LEED

Criteria	Credit	Requirements	Points
Sustainable sites	Credit 5.1	Site Development—Protect or Restore Habitat	1
	Credit 5.2	Site Development—Maximize Open Space	1
	Credit 6.1	Stormwater Design—Quantity Control	1
	Credit 6.2	stormwater Design—Quality Control	1
	Credit 7.2	Heat Island Effect—Roof	1
Water Efficiency	Credit 1	Water Efficient Landscaping	2-4
Total points			9

Table 16. CASBEE

Concerned Items		Score	Weighting coefficient
LR3 Off-site Environment		-	0.3
1	Consideration of Global Warming	-	-
2	Consideration of Local Environment	3.0	0.5
2.1	Air Pollution	3.0	0.25

	Heat Island Effect		3.0	0.5
3	Consideration of Surrounding Environment		3.0	0.5
3.1	Noise, Vibration and odor		3.0	0.4
	1	Noise	3.0	0.33
	2	Vibration	3.0	0.33

Table 17. Green Mark

Part 3	Environmental protection	Points allocation
NRB 3-3	Greenery provision	8
NRB 3-7	Storm water management	3
Part 5	Other green features	Points allocation
NRB 5-1	Green features and Innovation	7
TOTAL POINTS		18

Table 18. GBI

Item	Criteria	Features	Points
sustainable Site Planning & Management (SM)	SM11	Storm water Design – Quantity & Quality Control	1
	SM12	Greenery & Roof	2
Water Efficiency (WE)	WE3	Water efficient-Irrigation/ landscaping	2
	WE4	Water efficient fittings 2	2
Total Points			7

Overall result is shown in table 19 on the available points given for green roof system and the percentage of the points.

Table 19. Points allocation for green roof from 5 sustainable tools.

	BREEAAM	**LEED**	**CASBEE**	**Green Mark**	**GBI**
Total available points	110	110	BEE= 3.0	190	100
Available points for green roof	11	9	-	18	7
% points for green roof	10%	8.2 %	-	9.5 %	7 %

Discussion

Green building assessment is the new method in determining the sustainability in the built environment. Each of the tools intended for the sustainability in construction sector. Green roof systems are included in the evaluation criteria, although some tools put high emphasis while others do not. Several points worth being noted which are:

- All tools in the study can be evaluated in percentage, except for CASBEE method.

- BREAAM account for the most points for green roof system, a total of 10% from overall points. This is followed by Singapore's Green Mark 9.5%, LEED 8.25 and GBI 7%.
- The points accepted for inclusion in the green roof system are notably direct contribution such as greenery provision, greenery and roof and storm water design.
- Other factors that can contribute to green roof system are those that included in this study. These are criteria such as noise attenuation, air pollution reduction, insulation and biodiversity of animals. All these can be related with green roof and some may not be associated with. All these factors are taken considering the available opportunity for developers and major players in the construction business to emulate the criteria in the design and developing green roof system in their buildings.

BREEAM and LEED are the earliest available tools with its first inception in the year 1990 and 1998 respectively. The two models had become the blueprints of reference and adaptation of latest assessment tools. These early tool has develop and had seem many changes and update in term of its assess method and version. The changes are necessary due to current changes and rapid development of buildings and built environment as a whole.

CASBEE assessment tool method of assess is unique in its way of evaluation which differs from other available tools.

- The emergence of CASBEE are stand alone and not relying on any of the available assessment tools available at the time of its develop.
- CASBEE assessment tool is relatively difficult to assess in specific area due to its weighted system. The system are based on environment quality and environment load.
- Therefore to calculate weighted points for green roof system in CASBEE tool is unavoidably impossible at this instance of time.

Malaysian GBI is the youngest available tool among the tools evaluated. According to the result obtained, GBI score a mere 7% in green roof points. Emphasis in GBI is more towards energy efficient since the energy consumption in tropical country is relatively high. This tend to put the weightage more on energy factor, which are not related to green roof system whether directly or indirectly.

The adaptation of GBI is not entirely from Singapore's Green Mark, this can be said due to the items and criteria in the evaluation. Energy efficiency is very obvious a huge of amount of percentage of 116 out of 190 maximum points. It is about 61% out of the total percentage for Green Mark. Being said that it is the concern of a tropical country to emphasize on energy efficient building. This is evident for Singapore, as well as Malaysia since both countries having high temperatures throughout the year with hot and humid with little temperature difference. The electricity bills due to air conditioning for conventional buildings would generally cost high which makes the foundation of these tools in tropical climate to give more attention on energy savings.

Conclusion

Many would agree that establishing and formation of green building and sustainable building rating tools are huge contribution to environment aspect. Nevertheless the issue of investing considerable amount of monetary aspect would hinder some parties in not involving into green building assessment scheme. Certain measure have to be taken for instance providing tax exemption or rebate when a company is registering to participate in green building scheme.

Implementing green roof would benefit the developers, architect, engineers and investors in the later future. In a country where a tool give high percentage for a green roof, which can also benefits from an indirect aspect of a building criteria will give advantages for interested parties. In the United Kingdom or in any countries that used this assessment tools are likely to be benefited from the

implementation of green roof. The tool gives 10% for green roof construction and other relevant criteria for green roof contribution.

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